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RADIOFREQUENCY RADIATION SAFETY OF TWO MANPACK TRANSCEIVERS (AN/PRC-515 AND AN/PRC-77)

by

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DEFENCE RESEARCH ESTABLISHMENT OTTAWA
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ABSTRACT

The radiofrequency radiation (RFR) safety of two Canadian Forces manpack transceivers (AN/PRC-515 and AN/PRC-77) has been studied by a university contractor. This note explains the relationship of his study to current thinking in the field of RFR safety, summarizes his main findings, and applies them to DND operations. It is concluded that both transceivers are safe under all practical operating conditions.

RÉSUMÉ

L'étude des radiations émises par deux émetteur-récepteurs portatifs des Forces canadiennes (AN/PRC-515 et AN/PRC-77) a été confiée, par contrat, à une université. Le présent résumé explique le lien entre l'étude et les connaissances actuelles dans le domaine des radiations radiofréquences, en résume les principales conclusions et les applique aux opérations du MDN. L'étude conclut que les deux émetteur-récepteurs sont sûrs, dans toutes leurs conditions pratiques d'utilisation.



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1.0 INTRODUCTION

DND has defined a radiofrequency radiation (RFR) safety program. The program administration is outlined in a Canadian Forces Administrative Order [1] and the technical aspects are explained in a Canadian Forces Technical Order (CFTO) [2].

The scientific basis of the program is essentially the same as that of the current civilian standards in Canada [3] and the United States [4]. The DND RFR safety standard may be explained as follows:

- (1) The permitted exposure levels (PELs) for radiofrequency radiation workers should not be exceeded. These limits are given in Table I.

TABLE I
PERMITTED EXPOSURE LEVELS FOR DIFFERENT
EXPOSURE TIMES AND FREQUENCY RANGES*

Frequency Range	Permitted Exposure Levels (PELs)** (mW/cm ²)		
	1 hour	6 min	1 min
1 MHz - 3 MHz	33	66	165
3 MHz - 10 MHz	5	10	25
10 MHz - 1 GHz	1	2	5

* Data taken from Fig. 3-1 of [2]

** PELs depend on the time over which they are averaged

- (2) The exposure of a person near a manpack transmitter occurs in the "near field" of the antenna. In this case, the permitted exposure levels must be converted to units of squared electric and/or magnetic field strengths. Since the electric field is considered more important for safety, and since it is the only field that can be measured at 2 MHz with commercial instruments, this report will only deal with electric field strength measurements in the near field of the antenna. The power-density exposure limits of Table I may be converted to squared electric field strength figures using Table II.

TABLE II
CONVERSION OF POWER DENSITY TO ELECTRIC FIELD STRENGTH
AND SQUARED ELECTRIC FIELD STRENGTH*

Power Density (mW/cm ²)	Equivalent Electric Field Strength, E, or Squared Field Strength, E ² (round numbers)	
	E (V/m)	E ² (V ² /m ²)
1	60	4 000
2	90	8 000
5	140	20 000
10	200	40 000
25	300	90 000
33	350	120 000
66	500	250 000
165	800	600 000

*Data taken from Fig. 3-2 of [2]

- (3) Two exclusions to the PELs are permitted. These are, (from paras 4.2(1) and (2) of [4]):
- (a) At frequencies between 300 kHz and 100 GHz, the PELs may be exceeded if the exposure conditions can be shown by laboratory procedures to produce specific absorption rates (SARs) below 0.4 W/kg as averaged over the whole body, and spatial peak SAR values below 8 W/kg as averaged over any one gram of tissue.
 - (b) At frequencies between 300 kHz and 1 GHz, the PELs may be exceeded if the radio frequency input power of the radiating device is seven watts or less.

2.0 INITIAL SAFETY ASSESSMENTS

2.1 AN/PRC-77 VHF Transceiver

The AN/PRC-77 is an FM transceiver operating from 30 to 76 MHz. It is considered safe because it radiates no more than four watts of RF power, which is less than the seven watts permitted in para 3(b).

2.2 AN/PRC-515 HF Transceiver

This set transmits AM radiation (CW or SSB) in the HF band (2-30 MHz). Since it radiates 20 to 30 watts in the high-power mode, it is not excluded from the exposure standard based on the amount of radiated power (para 3(b)).

The exposure fields for the AN/PRC-515 used with the eight-foot whip antenna, were measured by QETE. High electric-field exposures were found [5]. For the case of the radio set worn on the operator's back, the measured fields at the back of the operator's head were found to exceed the exposure limits. This is illustrated in Table III, where four of the measurements were made by QETE [5], and the other two measurements (at 4 and 8 MHz) were done by a DND contractor in a subsequent study [6].

TABLE III
COMPARISON OF MEASURED AND PERMITTED ELECTRIC EXPOSURE
FIELDS FOR THE AN/PRC-515 MANPACK TRANSMITTER

Frequency (MHz)	Squared Electric Field (1000 V ² /m ²)		
	Permitted Exposure		Measured Exposure*
	6 min	1 min	
2	250	600	560**
4	40	90	(780)***
8	40	90	(330)
12	8	20	270
20	8	20	90
30	8	20	15

* Measured 20 cm from the 8' whip antenna, at the back of the operator's head. Transmitter used in the high-power (20 - 30W) CW mode.

** Data taken from Table 2, of ref. 5.

*** Data in brackets taken from pp. 80 and 81 of ref. 6, (scaled up from low power to high power).

It is obvious from the data in the table that even the one-minute exposure limits are often exceeded.

At this point, the only remaining options are to restrict the use of the AN/PRC-515 for high-power transmissions, or to study the safety of the set by the techniques outlined in para 3(a). The latter approach was taken - the specific absorption rates in models of the human body were determined

by laboratory procedures and the results compared to the SAR limits given in para 3(a) of section 1.

3.0 SPECIFIC-ABSORPTION-RATE STUDIES

3.1 General

Dr. S.S. Stuchly, of the University of Ottawa, was contracted by DREO to determine the SAR distribution in models of man exposed to the radiation fields of the AN/PRC-515. His group constructed two models of the human body and filled them with gel materials representing the average dielectric properties of the human body. To test the realism of one of the models, DREO measured its whole-body absorption rate inside a very large exposure facility used for measuring human whole-body RF absorption rates [7]. The model was found to absorb at a rate which is 50 percent greater than the rate measured for the average human subject [8]. Thus, we will assume that the models also absorb 50 percent more than a man would when exposed to the near-field radiation from a manpack source.

The effect of a helmet on the SAR in the head could not be tested because there was no way to realistically fit a helmet around the head of the models.

The effect of a rifle carried on a man's shoulder was simulated, and the metal barrel was shown to cause negligible changes in the pattern of RF absorption in the body.

3.2 Peak SAR

Both the exposure-field patterns and the SAR distribution were found to be quite uniform. Thus, no hot spots with a peak SAR > 8 W/kg were found.

3.3 Whole-Body Average SAR

For continuous operation at low power at all frequencies (2 - 30 MHz), the whole-body average SAR did not exceed the limit of 0.4 W/kg. For continuous operation at high power, the same result was obtained at frequencies from 4 to 30 MHz.

On the other hand, for continuous high-power operation at 2 MHz, the whole-body average SAR values, summarized in Table IV, were found to exceed the limit of 0.4 W/kg.

TABLE IV
WHOLE-BODY AVERAGE SAR FOR HIGH-POWER
OPERATION OF THE AN/PRC-515 AT 2 MHz

Transmitter On	Human Model*	SAR (W/kg)	
		Continuous Operation	Duty Cycle OF 1/6
Shoulders	simple better	1.5 - 2.3 0.4 - 1.1	0.25 - 0.38 0.07 - 0.18
Ground	simple better	0.3 - 0.6 0.7	0.05 - 0.10 0.12

*The better model has a more realistic shape and uses two different dielectric materials for the brain and the body.

The SAR limit of 0.4 W/kg is intended to be averaged over any six-minute period. Thus, it is necessary to correct for the transmitter duty cycle. The standard operating procedure for the AN/PRC-515 limits transmissions to 30 seconds duration. The design duty cycle (transmission time/receive time) is 1/9. Under adverse operating conditions the worst-case duty cycle may be taken to be 1/6. Therefore, any given set is unlikely to transmit more than one minute out of every six minute period.

The continuous-exposure SAR data of Table IV have been corrected, in the last column, to take into account this worst-case duty cycle. The highest SAR values are reduced to 0.38 W/kg for the set used on the shoulders, and to 0.12 W/kg for the set used on the ground. It should also be noted that these figures are likely high by about 50 percent, due to the inexactness of the model, as explained earlier.

4.0 SAFETY CONCLUSIONS

From the SAR results, it is concluded that there is no radiofrequency radiation hazard for the AN/PRC-515 under any practical operating condition. The other warnings issued with the set should still be observed, of course. These include the danger of RF burns from touching the antenna, especially at the lower frequencies, and the possibility of electrocution, should the whip antenna touch bare overhead power lines.

The AN/PRC-77 is also considered safe because it only radiates four watts of RF power. This conclusion is supported by the contractor's estimate that the SAR in a body exposed to a radiating AN/PRC-77 is only a few milliwatts/kg.

5.0 REFERENCES

- [1] CFAO 34-51, Radiofrequency Radiation Safety, Issued 6 Nov. 81, by DEMPS.
- [2] CFTO C-55-040-001/TS-001, Radiofrequency Radiation Safety - Technical Requirements and Precautions, Issued 1984 by DEMPS.
- [3] Safety Code 6 - Recommended Safety Procedures for the Installation and Use of Radiofrequency and Microwave Devices in the Frequency Range 10 MHz - 300 GHz, Publication 79-EHD-30, Health and Welfare Canada, 1979.
- [4] American National Standard - Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields (300 kHz - 100 GHz, ANSI standard C95.1 - 1982.
- [5] Non-Ionizing Radiation Levels Near Manpack Sets AN/PRC-77 and AN/PRC-515, 26 Jun 80, QETE project A02307.
- [6] G. Hartsgrove and S.S. Stuchly, Final Report - Radiofrequency Absorption Studies for Two Portable Radiocommunications Sets, The University of Ottawa, Department of Electrical Engineering, June 1983.
- [7] D.A. Hill, "Human Whole-Body Radiofrequency Absorption Studies Using a TEM-Cell Exposure System", IEEE Trans. Microwave Theory Tech., Vol. 30, pp. 1847-1854, 1982.
- [8] D.A. Hill, "The Effect of Frequency and Grounding on Whole-Body Absorption of Humans in E-Polarized Radiofrequency Fields", Bioelectromagnetics, Vol. 5, pp. 131-146, 1984.

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